LARGE MOUTH CENTRIFUGE LABWARE

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FIELD OF THE INVENTION

This invention relates generally to centrifuge labware and, more specifically, for large volume centrifuge labware.

BACKGROUND OF THE INVENTION

Centrifuges provide a very common method for separating mixtures in a laboratory setting. Sample mixtures in need of separation are placed in a plurality of individual

containers called "centrifuge labware." The samples are then rotated at high speed within the centrifuge until the various components of the mixture are separated by centrifugal force. The most commonly used centrifuges are designed to handle labware of relatively small volume. The labware is typically test tube shaped and the labware is disposed within the centrifuge at a fixed angle with respect to the vertical.

For separating samples of larger volume, swinging bucket centrifuges are employed. Such swinging bucket centrifuges are designed to handle labware having a volume capacity of up to a liter or more. In a swinging bucket centrifuge, the labware is initially retained within hinged buckets, such that the labware is initially retained in a vertical orientation. During operating of the centrifuge, centrifugal forces acting on the bucket cause the buckets to rotate about the hinges outwardly whereby the labware becomes disposed at an angle with respect to the vertical.

Large volume labware is commonly used to grow and eventually harvest genetically engineered bacteria and other simple cellular materials. The bacteria and/or other cellular materials are grown within a nurturing liquid ("broth") disposed within large "fermentors" having a typical capacity of 1 - 1000 liters. At the end of the growing cycle, a portion of the nurturing liquid is placed into the labware and the labware is then loaded into a swinging bucket centrifuge. In the centrifuge, the labware is rotated at high speed until the biological material is concentrated at the bottom of the labware in a mass commonly termed a "pellet." After separation in the centrifuge, the remaining liquid material ("supernatant") is decanted off and the pellet is "harvested," typically by scraping the pellet off of the bottom of the labware using a spatula or similar tool.

Prior art large volume labware useable in such biotechnical, bioindustrial and biopharmaceutical applications typically are containers having flat bottoms, narrow openings and a screw top lid. There are several problems inherent in such labware. The flat bottoms mean that the junction of the bottom wall with the vertical side walls defines a circumferential

edge where it may be difficult to remove the pellet. Moreover, in prior art labware having a non-round cross-section, the junction of the bottom wall with the vertical side walls will also define a plurality of corners from which it can be very difficult to remove pellet material.

In addition, the relatively narrow opening at the top of such prior art labware makes it difficult to remove pellets from the bottom of the labware.

Still further, the screw top lid of such prior art labware does not seal well in the centrifuge. This is because when the centrifuge is operating, the container portion of the labware tends to elongate under the high centrifugal forces. Such elongating of the container portion tends to narrow the top opening and loosens the seal with the screw cap.

Yet another problem with such prior art labware is the relative impossibility of constructing and using a practical liner which will protect the labware and facilitate the cleaning of the labware.

Yet still another problem with such prior art labware is the relative difficulty of decanting off liquid material through the top opening without spilling or dribbling some of the liquid material. Because the liquid material can contain potentially toxic material, this can pose a health risk to laboratory personnel.

Accordingly, there is a need for centrifuge labware which avoids some or all of the aforementioned problems in the prior art.

SUMMARY OF THE INVENTION

The invention satisfies this need. The invention is a centrifuge labware device comprising a container and a lid. The container comprises a bottom wall and one or more

substantially vertical sidewalls. The bottom wall and the one or more side walls cooperate to define an interior chamber having an interior chamber cross-sectional area. The container has a top opening defining a top opening open area which is at least about 90% of the interior chamber cross-sectional area. The lid is removable and non-threaded. The lid is sized and dimensioned to cover the top opening so as to seal the interior chamber.

DESCRIPTION OF THE DRAWINGS

These and other features, aspects and advantages of the present invention will become better understood with reference to the following description, appended claims and accompanying drawings where:

Figure 1 is a perspective view of a centrifuge labware having features of the invention;

Figure 2 is an exploded perspective view of the labware illustrated in Figure 1;

Figure 3 is a half-section view of the container portion of the labware illustrated in Figure 1;

Figure 3A is a detailed view of one edge of the container illustrated in Figure 3,

Figure 3B is a detailed view of a second edge of the container illustrated in Figure 3;

Figure 4 is a perspective view of a lid attachment clip and handle useable in the invention;

Figure 5 is a plan view of the container portion illustrated in Figure 3;

Figure 6 is a plan view of the labware illustrated in Figure 1;

Figure 7 is a half section view of the labware illustrated in Figure 1;

Figure 7A is a detailed view of one edge of the labware illustrated in Figure 7;

Figure 8 is a bottom view of the lid portion of the labware illustrated in Figure 1;

Figure 9 is a side view of the lid portion of the labware illustrated in Figure 8;

Figure 9A is a cross-sectional detail view of the spout portion of the lid illustrated in Figure 9;

Figure 10 is a plan view of the lid portion illustrated in Figure 8;

Figure 11 is a perspective view of the lid portion illustrated in Figure 8; and

Figure 12 is a perspective view of a centrifuge wherein is disposed the labware illustrated in Figure 1.

DETAILED DESCRIPTION

The following discussion describes in detail one embodiment of the invention and several variations of that embodiment. This discussion should not be construed, however, as limiting the invention to those particular embodiments. Practitioners skilled in the art will recognize numerous other embodiments as well.

The invention is a centrifuge labware **10** comprising a container **12** and a lid **14**. In the embodiment illustrated in the drawings, the container **12** is a large mouth device comprising a bottom wall **16** and one or more substantially vertical side walls **18**. The bottom wall **16** and the one or more side walls **18** cooperate to define an interior chamber **20** with a top opening **22**. The container **12** is typically molded from a high strength thermoplastic material, such as a polyphenylsulfone. One such polyphenylsulfone is Radel R1000 marketed by BP Amoco Performance Products of Alphareta, Georgia. The container **12** has a very high axial strength, that is, a very high strength along its longitudinal axis such that the container can withstand at least about 1000 x g, preferably at least about 4000 x g, and most preferably greater than about 5000 x g, applied to the interior surface **24** of the bottom wall **16**.

The one or more side walls **18** of container **12** can be translucent or transparent so as to allow the user to readily recognize the height of the liquid material within the container **12**. In such embodiments, the one or more side walls **18** can also be graduated with volume indicating markers.

The embodiment illustrated in the drawings has a generally oval cross-section, having a first transverse axis **26** and a second transverse axis **28** disposed substantially perpendicular to the first transverse axis **26**. The first transverse axis **26** can be of the same length as the second transverse axis **28**. In the embodiment illustrated in the drawings, the first transverse axis **26** is longer than the second transverse axis **28**. In all cases, it is preferred that both the first and second transverse axes **26** and **28** be at least about 9 cm in length to facilitate the removal of a pellet on the bottom wall **16** of the container **12**.

The interior chamber **20** of the container **12** has an interior chamber cross-sectional area and the top opening **22** defines a top opening area. The top opening area is at least about 90% of the interior chamber cross-sectional area. In the embodiment illustrated in the drawings, the top opening **22** is defined by a circumferential rim **30** running along the uppermost portions of the one or more sidewalls **18**. In this embodiment, the top open area is essentially the

same as the interior chamber cross-sectional area.

In the embodiment illustrated in the drawings, the cross-section of the container **12** is "pinched" at the second transverse axis **28**, so as to give the cross-section somewhat of a "figure 8" shape. This shape facilitates the attachment of the lid **14** across the top opening **22** of the container **12**. Because of this figure 8 shaped cross-section, the meniscus of liquid being centrifuged within the container **12** rises to a greater extent along the one or more side walls **18** at the second transverse axis **28**. To prevent the meniscus from rising above the circumferential rim **30**, the one or more side walls **18** proximate to the second transverse axis **28** are curved upwardly so that the height of the one or more side walls **18** proximate to the second transverse axis **28** is slightly higher in elevation than the remainder of the one or more side walls **18**.

The lid **14** is a removable, non-threaded structure having an exterior surface **32**, an interior surface **34** and a very high axial strength. By "very high axial strength," it is meant that the lid **14** can withstand axial pressures of at least about 1000 x g, preferably at least about 4000 x g, and most preferably 5000 x g, applied to the exterior surface **32** of the lid **14**. The lid **14** is sized and dimensioned to cover the top opening **22** so as to seal the interior chamber **20** of the container **12**.

In the embodiment illustrated in the drawings, the interior surface **34** of the lid **14** comprises a plurality of interconnecting reenforcement ribs **36** which cooperate to provide the lid **14** with its very high axial strength.

In the embodiment illustrated in the drawings, the interior surface **34** of the lid **14** also has a circumferential horizontal lid flange **38** with a width of at least about 3 mm, preferably at least about 5 mm. The horizontal lid flange **38** is sized and dimensioned to match with the circumferential rim **30** of the container **12** so that the lid **14** tightly seals the top opening **22** of the container **12**. To facilitate this seal, a gasket **40** is preferably disposed between the circumferential rim **30** and the horizontal lid flange **38**. As illustrated in Figure 7A, the top

surface **42** of the gasket **40** preferably defines a plurality of parallel ribs **44** which provide the top surface **42** of the gasket **40** with a tortuous path. Such tortuous path acts to enhance the seal between the lid **14** and the container **12** and minimizes any change of the liquid leaking or "aerosoling" from the labware **10** during use. The gasket **40** can be made from a silicone.

Preferably, the lid **14** further comprises a circumferential vertical lid flange **46** which is disposed downwardly below the horizontal lid flange **38** by a distance of at least about 3 mm, preferably at least about 5 mm. The vertical lid flange **46** is sized and dimensioned to be spaced apart from the circumferential rim **30** of the container **12** by at least about 1 mm. In embodiments having the vertical lid flange **46**, the seal between the lid **14** and the circumferential rim **30** is maintained even under extreme centrifuge conditions wherein the one or more side walls **18** of the container **12** expands and the top opening **22** of the container **12** distorts.

In the embodiment illustrated in the drawings, the lid **14** is readily attached and deattached from the container **12** by a hinged wire clip **48** having a pair of opposed attachment prongs **50**. The attachment prongs **50** engage corresponding attachment apertures **52** (see Figure 3A) defined within a hinge support post **54** which is disposed near the top of the one or more side walls **18** of the container **12**. In operation, the clip **48** nests within parallel clip grooves **56** defined within the exterior surface **32** of the lid **14** to minimize aerodynamic drag on the clip **48**. The clip **48** further comprises a horizontal catch member **58** which is reversibly retained within a retaining groove **60** disposed within a catch post **62**. The catch post **62** is disposed near the upper portion of the one or more sidewalls **18** of the container **12** opposite to the catch post **54** (see Figure 3B). The catch member **58** can be easily disengaged from the retaining groove **60** by pulling outwardly on a finger loop member **64**.

As illustrated in Figure 4, a carrying handle **66** is rotatably attached to the hinged clip **48** to facilitate the carrying of the labware **10**. The handle **66** is rotatably attached to the clip **48** so that it can fold against the exterior surface **32** of the lid **14** during operation, thereby

minimizing aerodynamic drag on the handle **66**. Both the clip **48** and the handle **66** can be made from a stainless steel wire.

The lid **14** can also further comprise a pouring spout **68** to facilitate the safe offloading of liquid from the fermentors to the labware **10** using a hose. Such offloading using a hose minimizes the danger of inadvertent splash back. The pouring spout **68** also facilitates the decanting of liquid material from the container **12** after centrifuging. The pouring spout **68** preferably comprises a removable self-sealing pouring spout cover **70**. By "self-sealing," it is meant that the pouring spout cover **70** tends to seal itself when the labware **10** is being rotated in a centrifuge. In the embodiment illustrated in the drawings, the pouring spout cover **70** is adapted to press fit into the pouring spout **68** along a path which is parallel to the longitudinal axis **72** of the container. Such self-sealing configuration minimizes the danger of liquid leakage or aerosoling during operation.

Preferably, the pouring spout **68** has a sharp forward edge **74** as illustrated in Figure 9A so that the decanting of liquid from the container to the pouring spout is drool free and is substantially drip-free. As illustrated in Figures 9A and 11, a circular trough-like depression **76** surrounds about three quarters of the periphery of the spout to create the sharp edge **74**.

It is also preferable that the pouring spout **68** has a downwardly directed portion **78** which extends below the circumferential horizontal lid flange **38**. The downwardly directed portion **78** facilitates the loading of the container **12** through the pouring spout **68** by providing the user with a convenient "sight glass" to recognize when the liquid level within the container **12** is approaching the upper edges of the one or more container side walls **18** by noting the formation of a meniscus-shaped fluid surface at the lowermost part **80** of the downwardly directed portion **78**.

The downwardly directed portion **78** also prevents the overfilling of the container **12** through the pouring spout **68**. Once the liquid level within the container **12** reaches the lowermost part **80** of the downwardly directed portion **78**, additional liquid delivered into the pouring spout **68** is prevented from entering the interior chamber **20** by the trapped air mass disposed immediately below the lid **14**. Excess liquid delivered into the spout **68** merely backs up into the spout **68** but does not enter the interior chamber **20**. This is generally true even in embodiments having an air vent aperture in the lid **14** as described in the next paragraph.

To facilitate the filling and decanting of liquid material to and from the container **12** through the pouring spout **68**, the lid **14** preferably further comprises an air vent filter **82**. The air vent filter **82** can be a polypropylene plug having a slight taper in the longitudinal direction so as to provide a slight interference fit with a corresponding air vent aperture **84** in the lid. Preferably, the air vent filter **82** is recessed within the lid **14** to minimize aerodynamic drag.

The lid **14** is typically molded from a high strength thermoplastic, such as a polyphenylsulfone. Like in the container **12**, a suitable polyphenylsulfone useable in the molding of the lid **14** is Radel R1000.

In the embodiment illustrated in the drawings, the exterior surface **32** of the lid **14** is generally smooth (except for the clip grooves **56**) so that a substantial portion of the exterior surface **32** of the lid **14** can be used as a writing surface for labware or sample identification.

A planar structural support **86** can be optionally used to provide the container **12** with additional axial support during centrifuging. Use of this structural support **86** also acts as a vortex breaker and to hold a container liner in place. The structural support **86** can be made from a thermoplastic, such as polyetherimide. A suitable polyetherimide is Ultem 1000 marketed by GE Plastics of Pittsfield, Massachusetts.

The structural support **86** can be conveniently inserted and removed from the container **12** by slipping the longitudinal support into a pair of opposed first structural support slots **88** disposed on opposite sides of the interior surface **90** of the one or more vertical side walls **18** of the container **12**, along the first transverse axis **26**.

In the embodiment illustrated in the drawings, the structural support **86** is curved upwardly along its uppermost edge **92**. The lowermost edge **94** of the structural support **86** is spaced apart from the bottom wall **16** of the container **12** to form a clearance gap **96**, so that a pellet can be formed along the bottom wall **16** of the container **12** without contacting the structural support **86**.

In the embodiment illustrated in the drawings, a pair of second structural support slots **98** are disposed on the interior surface **90** of the container **12** along the second transverse axis **28**. Such second structural support slots **98** can be used to retain a second planar structural support (not shown) disposed perpendicular to the first structural support **86**. Cooperation of the first structural support **86** and the second structural support can be used to segregate the interior chamber **20** of the container **12** into four separate subchambers.

The drawings also illustrate the use of an optional liner **100**. The liner **100** is sized and dimensioned to closely follow the contours of the interior surfaces of the container walls **16** and **18**. Preferably, the liner **100** can be inserted and removed from the container **12** by hand without use of special tools. The liner **100** can be any suitable flexible or semi-rigid material which supports samples or other fluids. The liner **100** can be made from a low density polyethylene. Liners **100** useable in the invention can be of the type described in U.S. Patent Application Serial No. 09/607,232, filed June 30, 2000 under the title "Removable Conformal Liners for Centrifuge Containers," the entirety of which is incorporated herein by this reference.

In the embodiment illustrated in the drawings, the liner **100** has one or more vertical side walls **102** which terminate in an outwardly directed circumferential horizontal liner

flange **104**. In this design, the circumferential horizontal liner flange **104** is assembled within the labware **10** of the invention between the circumferential rim **30** of the container and the circumferential horizontal lid flange **38**. Because the horizontal liner flange **104** is "sandwiched" between the circumferential rim **30** and the horizontal lid flange **38**, the liner **100** is held firmly in place and is prevented from folding over on itself.

The labware of the invention can be conveniently used in a wide variety of centrifuges **106**, such as the Avanti J and J2 family of centrifuges marketed by Beckman Coulter, Inc., of Fullerton, California.

EXAMPLE

In one embodiment of the invention, the container **12** has a first transverse axis **26** measuring 177.8 mm and a second transverse axis **28** measuring 137.2 mm. The overall height of the container **12** is 168.7 mm. The bottom wall **16** of the container **12** has a radius of curvature of 115.1 mm. The upper portions **108** of the one or more side walls **18** at the second transverse axis **28** have a radius of curvature of 821.2 mm. The exterior surface **32** of the lid **14** has a radius of curvature of 254.0 mm. The overall height of the labware **10** is 204.7 mm. The design volume of the labware **10** is 2.25 liters. Both the container **12** and the lid **14** are made from polyphenylsulfone. The hinged clip **48** and the handle **66** are made from stainless steel. The structural support **86** is made from polyetherimide. The liner **100** is made from low density polyethylene. The gasket **40** is made from food grade silicone and the air vent filter **82** is made from polypropylene. This embodiment is designed for use in an Avanti J-HC Centrifuge and JS-5.0 rotor.

Having thus described the invention, it should be apparent that numerous structural modifications and adaptations may be resorted to without departing from the scope and fair meaning of the instant invention as set forth hereinabove and as described hereinbelow by

the claims.